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(54) **METHOD FOR AUTOMATIC ADJUSTMENT OF PEDELEC**

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 B62M 6/50   (2010.01)
(52) **U.S. Cl.**
 CPC *B62M 6/45* (2013.01)
(58) **Field of Classification Search**
 CPC combination set(s) only.
 See application file for complete search history.

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(57) **ABSTRACT**

A method for automatic adjustment of a pedelec having a first assist level and a second assist level includes the following steps. The pedelec is operated at an initial assist level. A pedal torque index is measured and compared with a predetermined numeric section having an upper threshold and a lower threshold. If the pedal torque index is within the predetermined numeric section, the pedelec is kept in operating at the initial assist level. If the pedal torque index is lower than the lower threshold, the pedelec is adjusted to operate at the second assist level. If the pedal torque index is higher than the upper threshold, the pedelec is adjusted to operate at the first assist level. Therein, auxiliary force provided by the pedelec at the second assist level is less than auxiliary force provided by the pedelec at the first assist level.
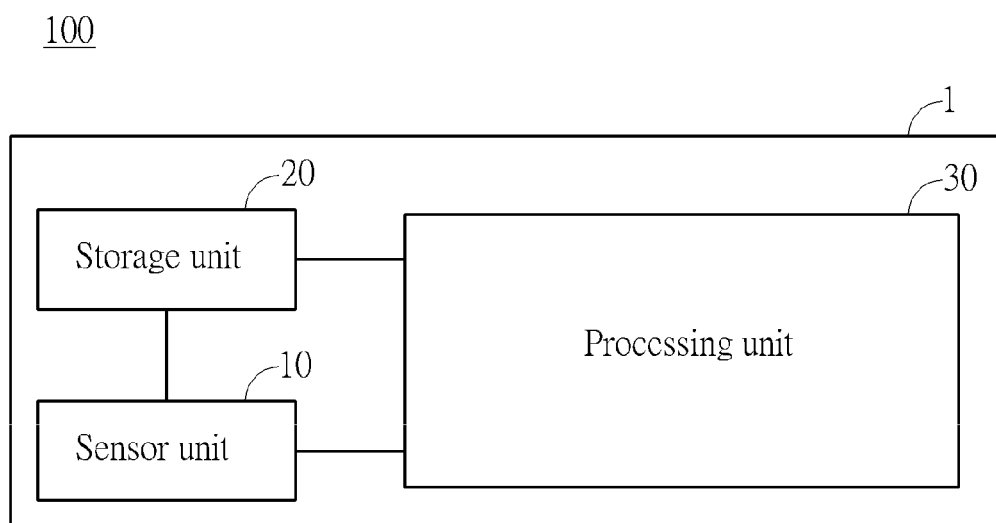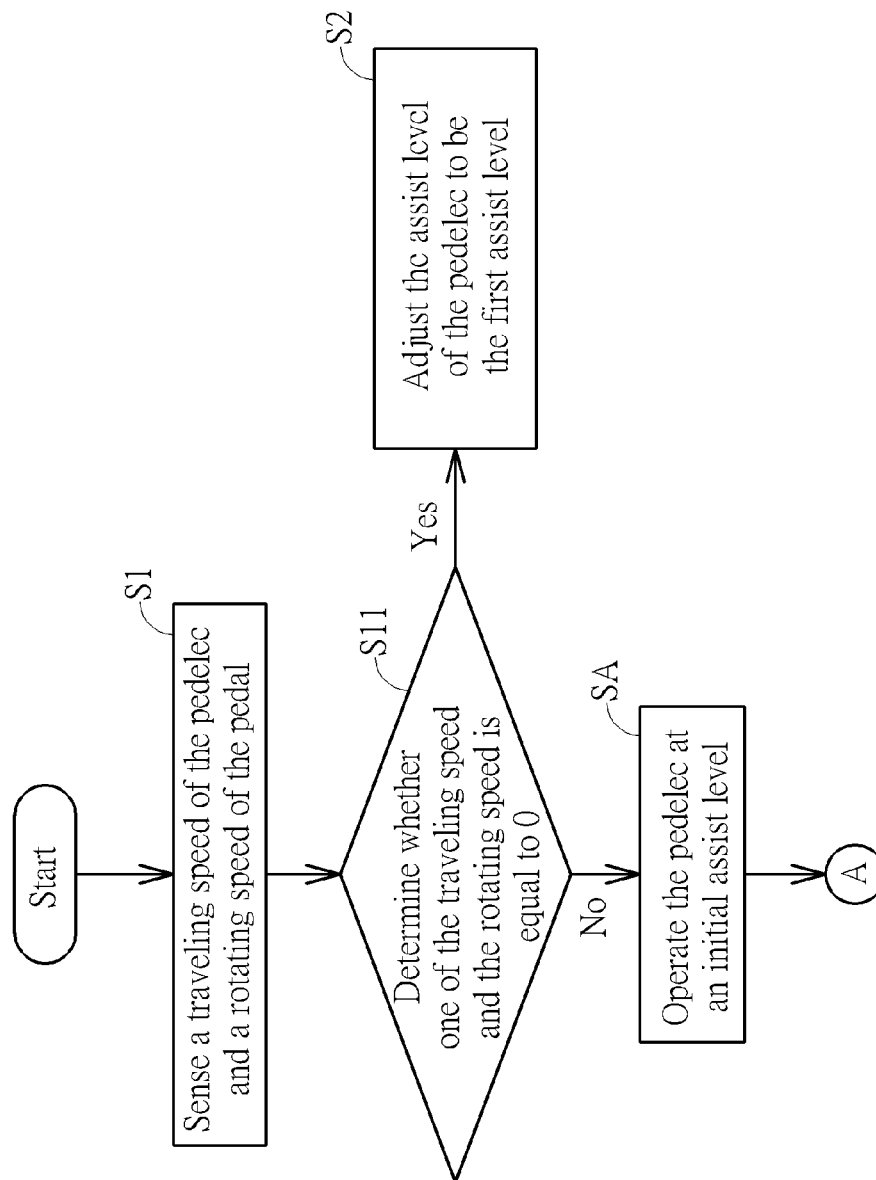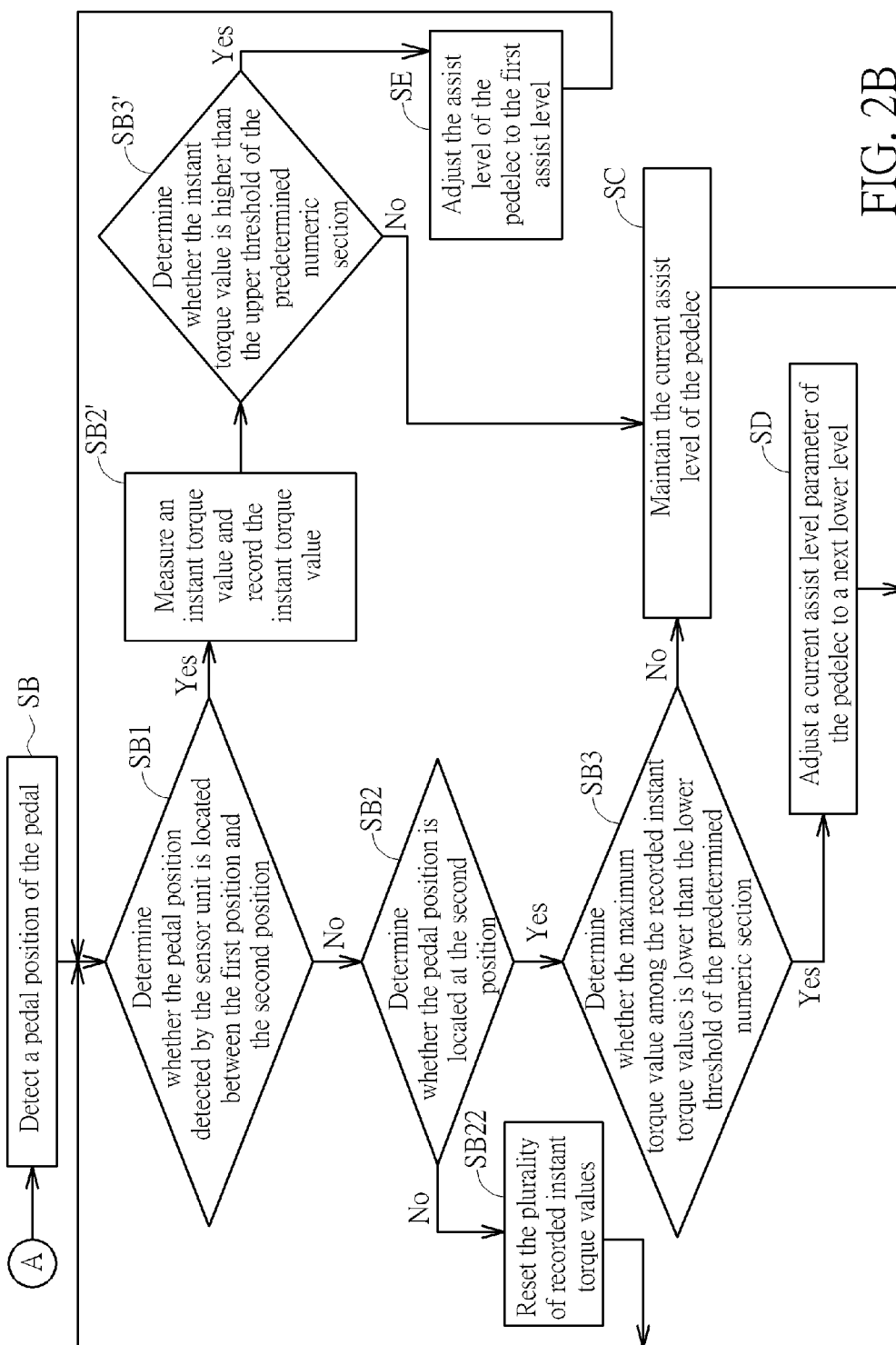
20 Claims, 8 Drawing Sheets

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FIG. 1

Start

S1
Sense a traveling speed of the pedelec
and a rotating speed of the pedal

S11
Determine whether
one of the traveling speed
and the rotating speed is
equal to 0

Yes

S2
Adjust the assist level
of the pedelec to be
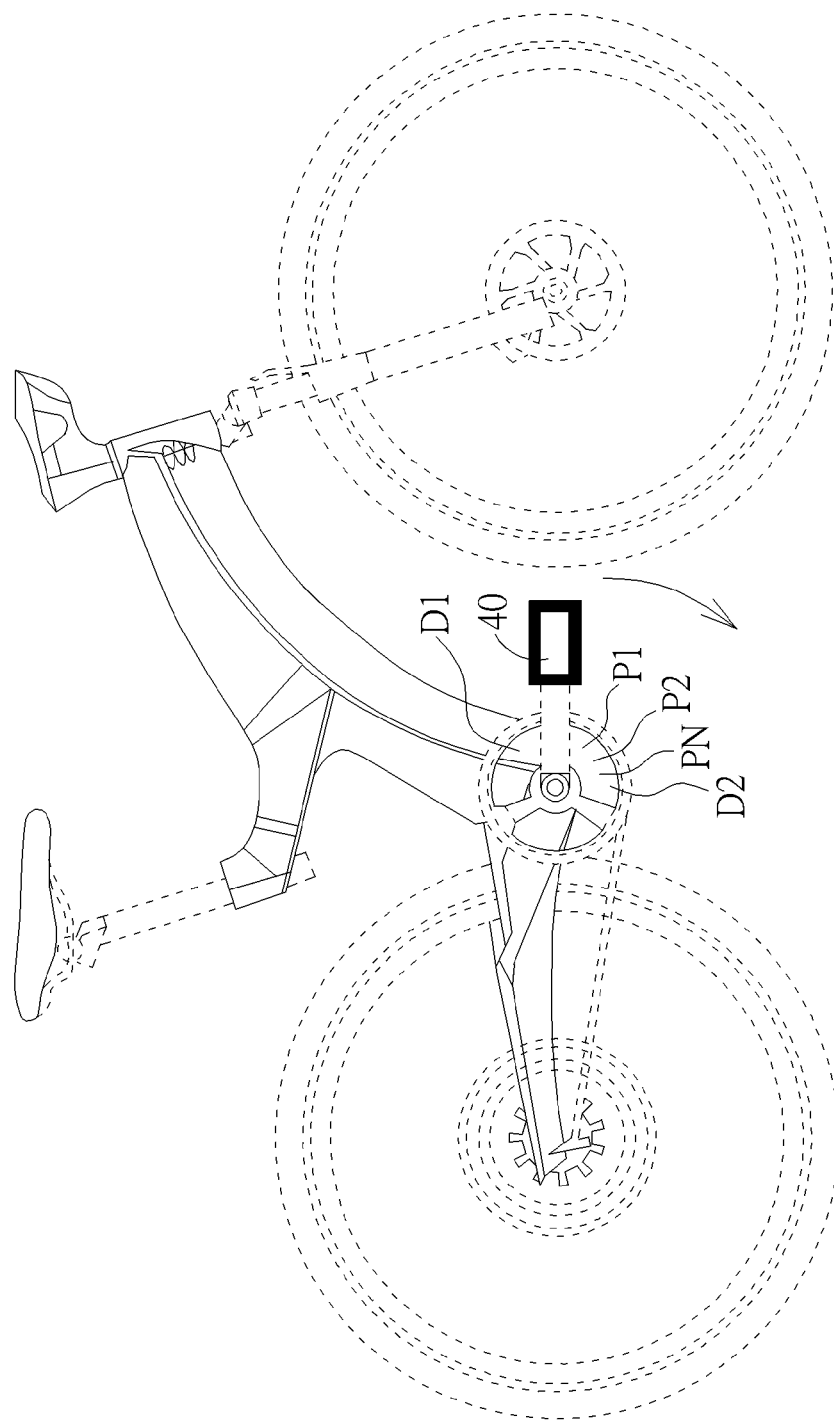the first assist level

No

SA
Operate the pedelec at
an initial assist level
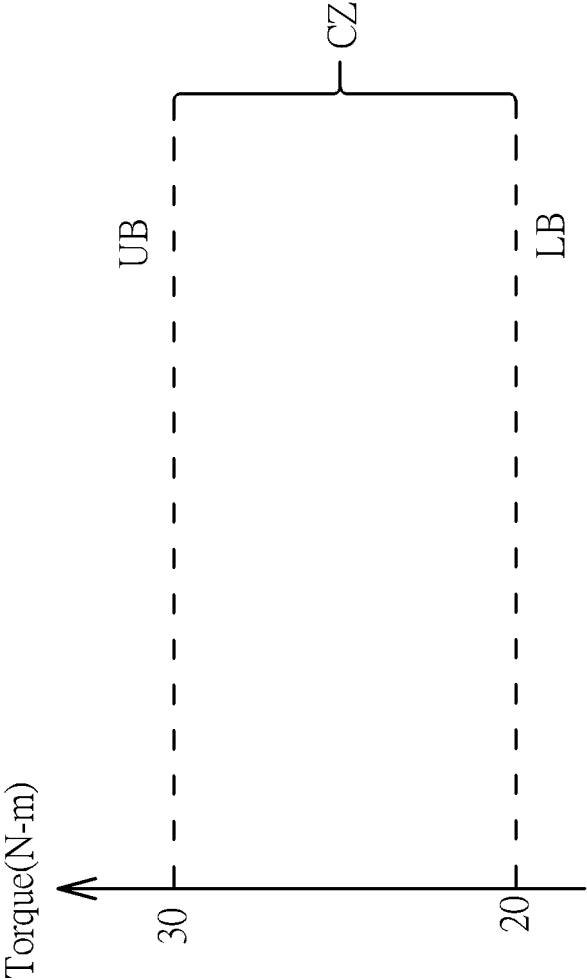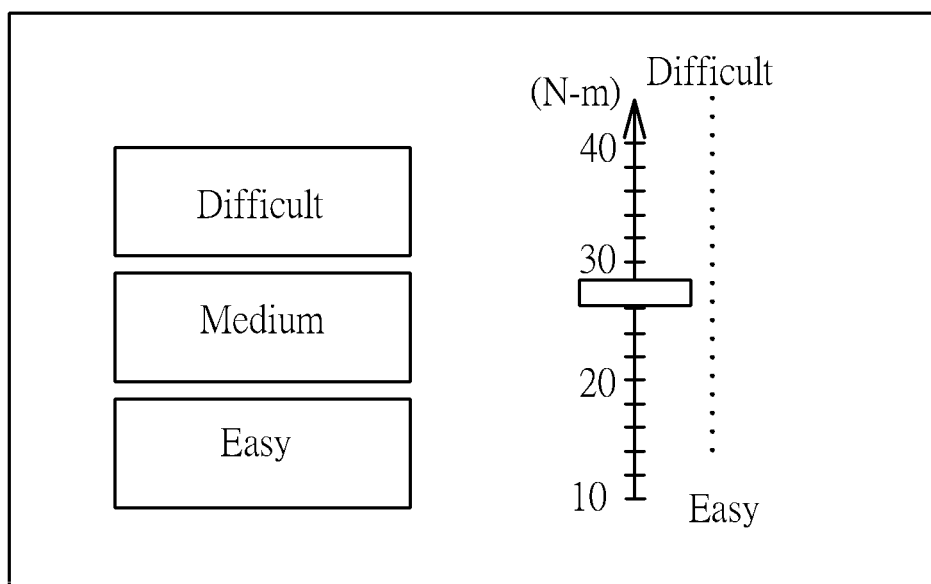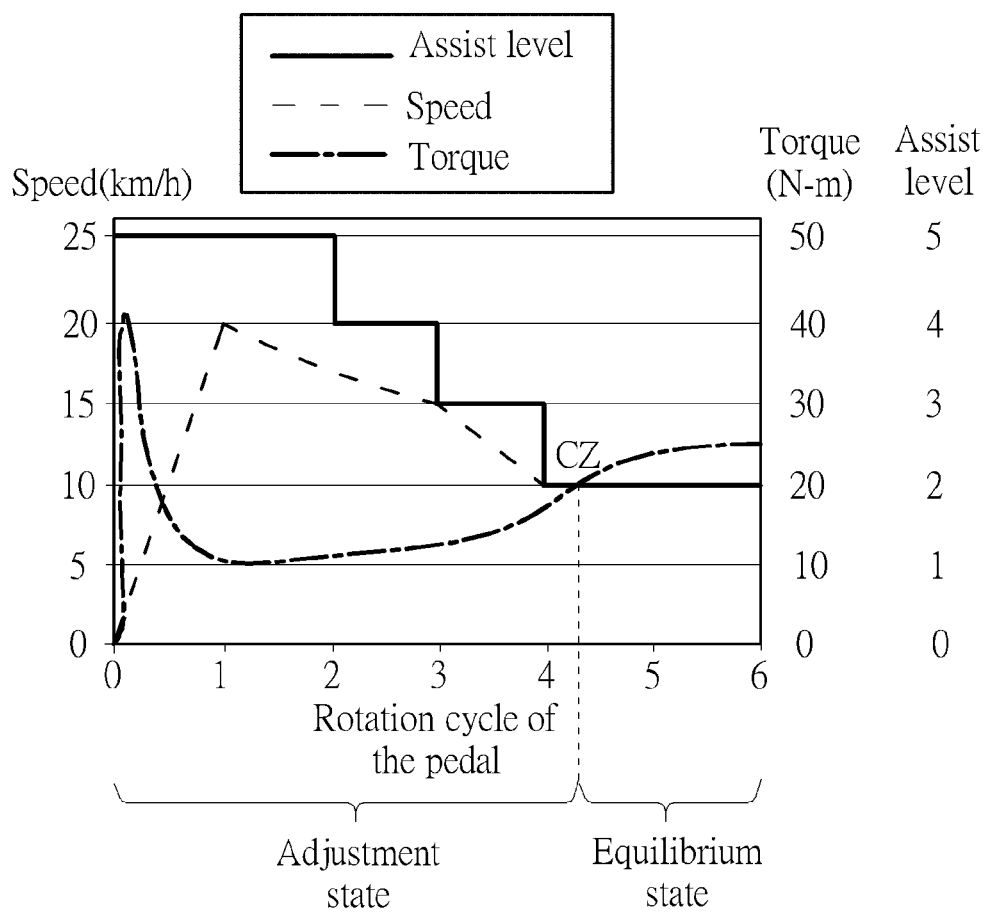
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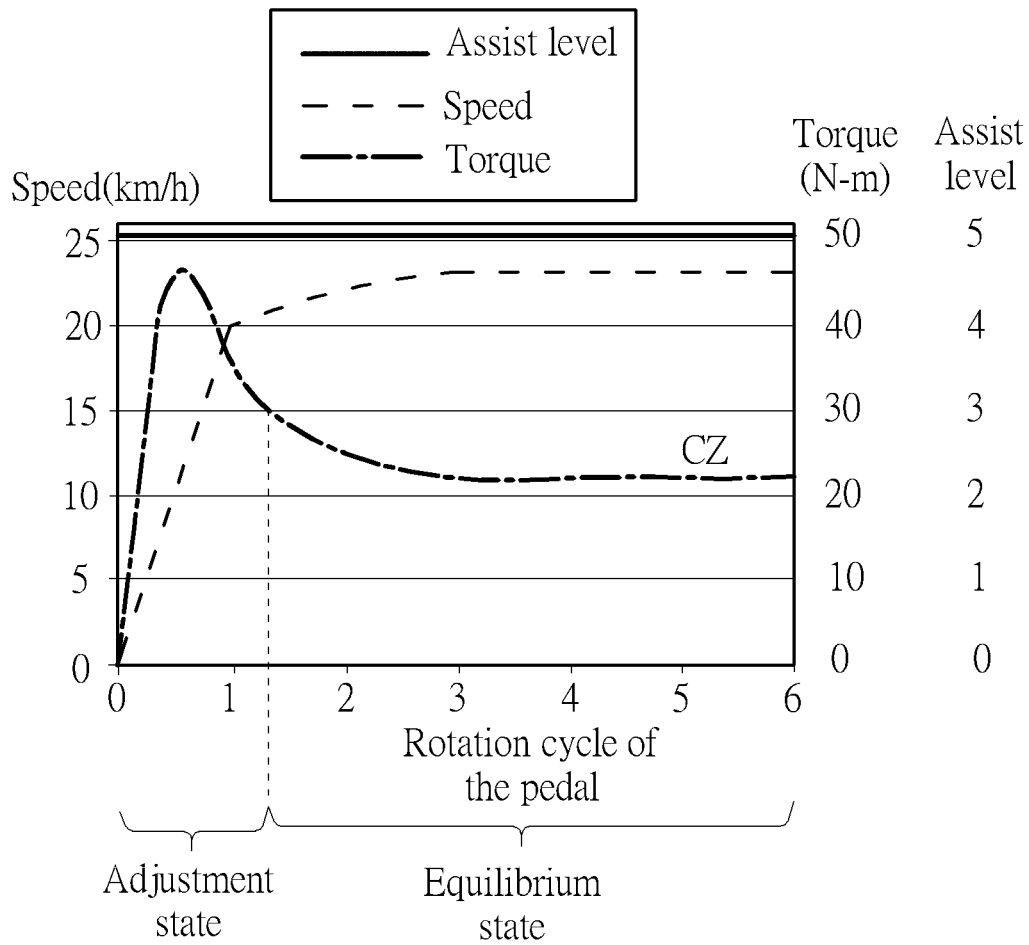FIG. 2A

FIG. 2B
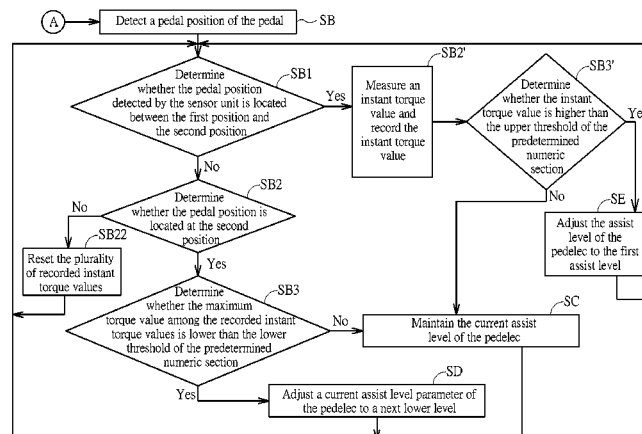
FIG. 3

FIG. 4

FIG. 5

FIG. 6

FIG. 7

METHOD FOR AUTOMATIC ADJUSTMENT OF PEDELEC

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a method for adjustment of a pedelec, and especially relates to a method for automatic adjustment of a pedelec.

2. Description of the Prior Art

A pedelec (i.e. a type of e-bike) allows a rider to adjust an assist level according to different road conditions, so that the rider can get into an easy and comfortable riding. However, a common pedelec has numerous and complex assist levels which are performed usually in company with a gear transmission, so the rider has to know about the gear transmission, which increases the manipulation complexity and the loading in study. Furthermore, when the rider needs to manually adjust the assist level, the rider often neglect a current assist level of the pedelec, a speed, and a force applied to a pedal, which probably leads to a discomfort due to void pedaling or an inadequate assist level after an adjustment.

Therefore, for an improvement to the above problems, the invention provides a method capable of automatically adjusting an assist level of a pedelec.

SUMMARY OF THE INVENTION

The invention relates to a method of automatically switching a pedelec to operate at a proper assist level according to a current speed of the pedelec, a cadence of a pedal of the pedelec, a torque applied to the pedal by a rider and so on, so that a rider can experience an easy and comfortable riding.

An objective of the invention is to provide a method for automatic adjustment of a pedelec. The pedelec has a first assist level and a second assist level. Auxiliary force provided by the pedelec at the second assist level is less than auxiliary force provided by the pedelec at the first assist level. The method for automatic adjustment includes the following steps: operating the pedelec at an initial assist level; measuring a pedal torque index and comparing the pedal torque index with a predetermined numeric section that has an upper threshold and a lower threshold; if the pedal torque index is within the predetermined numeric section, keeping the pedelec in operating at the initial assist level; if the pedal torque index is lower than the lower threshold, adjusting the pedelec to operate at the second assist level; and if the pedal torque index is higher than the upper threshold, adjusting the pedelec to operate at the first assist level.

An objective of the invention is to provide a method for automatic adjustment of a pedelec. The pedelec is capable of outputting auxiliary force at a first assist level, a second assist level, and a third assist level selectively. The auxiliary force provided by the pedelec at the first assist level is larger than the auxiliary force provided by the pedelec at the second assist level. The auxiliary force provided by the pedelec at the second assist level is larger than the auxiliary force provided by the pedelec at the third assist level. A next lower level for the first assist level is the second assist level. A next lower level for the second assist level is the third assist level. The pedelec includes a pedal. A rotation path of the pedal has a first position and a second position. The pedelec has a current assist level parameter and a predetermined numeric section. The predetermined numeric section has an upper threshold and a lower threshold. The method for automatic adjustment includes the following steps. The method is to assign one of the first assist level and the second assist level to the current

assist level parameter and to detect a pedal position of the pedal. When the pedal position is between the first position and the second position, the method is to measure and record an instant torque value, to assign the first assist level to the current assist level parameter if the instant torque value is higher than the upper threshold, and to maintain the current assist level parameter if the instant torque value is lower than the upper threshold. When the pedal position passes through the second position, the method is to determine a maximum torque value among a plurality of instant torque values measured and recorded during the pedal moving from the first position toward the second position, to adjust the current assist level parameter to the next lower level for the assist level that is assigned to the current assist level parameter if the maximum torque value is lower than the lower threshold, and to maintain the current assist level parameter if the maximum torque value is higher than the lower threshold.

An objective of the invention is to provide a method for automatic adjustment of a pedelec. The pedelec is capable of operating at a first assist level, a second assist level and a third assist level selectively. Auxiliary force provided by the pedelec at the first assist level is larger than auxiliary force provided by the pedelec at the second assist level. The auxiliary force provided by the pedelec at the second assist level is larger than auxiliary force provided by the pedelec at the third assist level. A next lower level for the first assist level is the second assist level. A next lower level for the second assist level is the third assist level. The pedelec has a pedal, a current assist level parameter, and a predetermined numeric section. The predetermined numeric section has an upper threshold and a lower threshold. The method for automatic adjustment includes the following steps: assigning one of the first assist level and the second assist level to the current assist level parameter; measuring a pedal torque index; comparing the pedal torque index with the upper threshold and assigning the first assist level to the current assist level parameter if the pedal torque index is higher than the upper threshold; comparing the pedal torque index with the lower threshold and adjusting the current assist level parameter to the next lower level for the assist level that is assigned to the current assist level parameter if the pedal torque index is lower than the lower threshold; and maintaining the current assist level parameter if the pedal torque index is higher than the lower threshold and lower than the upper threshold.

These and other objectives of the present invention will no doubt become obvious to those of ordinary skill in the art after reading the following detailed description of the preferred embodiment that is illustrated in the various figures and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a function block diagram of an automatically-adjusting device of a pedelec of an embodiment according to the invention.

FIGS. 2A and 2B are a flow chart of the method for automatic adjustment of the pedelec of the embodiment according to the invention.

FIG. 3 is a schematic diagram illustrating positions of a pedal of the embodiment according to the invention.

FIG. 4 is a schematic diagram illustrating a predetermined numeric section of the embodiment according to the invention.

FIG. 5 is a schematic diagram illustrating a plurality of degrees of difficulty of the predetermined numeric section of the embodiment according to the invention.

FIG. **6** is a schematic diagram illustrating varying of the assist level, the speed and a pedal torque of the pedelec relative to rotation cycles of a first embodiment according to the invention.

FIG. **7** is a schematic diagram illustrating varying of the assist level, the speed and a pedal torque of the pedelec relative to rotation cycles of a second embodiment according to the invention.

DETAILED DESCRIPTION

Please refer to FIG. **1**, which is a function block diagram of an automatically-adjusting device **1** of a pedelec **100** of an embodiment according to the invention. The automatically-adjusting device **1** of the pedelec **100** includes a sensor unit **10**, a storage unit **20**, and a processing unit **30**. The sensor unit **10** for example a sensing chip is used for sensing a traveling speed of the pedelec **100**, a pedal position of a pedal of the pedelec **100**, a rotating speed (or cadence) of the pedal, and a pedal torque index. The storage unit **20** for example a hard disk or a memory is used for recording pedal torque indices at different positions sensed by the sensor unit **10**. The processing unit **30** for example is a processor or a controller chip is used for adjusting an assist level of the pedelec **100**, determining the traveling speed of the pedelec **100** and the rotating speed of the pedal, and comparing the pedal torque indices at different positions with a predetermined numeric section. Then the processing unit **30** can adjust the assist level of the pedelec **100** according to the comparison result.

The above pedelec **100** can have a first assist level and a second assist level. Auxiliary force provided by the pedelec **100** at the second assist level being is than auxiliary force provided by the pedelec **100** at the first assist level. Furthermore, a method for automatic adjustment of a pedelec is implemented in the automatically-adjusting device **1** of the pedelec **100**.

Please refer to FIGS. **2A** and **2B**, which are a flow chart of the method for automatic adjustment of the pedelec **100** of the embodiment according to the invention; therein, FIG. **2B** follows FIG. **2A**. The components of the pedelec **100** will be described in detail with the flow chart in the following. However, the steps in FIGS. **2A** and **2B** are not limited to be applied only to the pedelec **100** in FIG. **1**; the pedelec **100** in FIG. **1** is not limited to use only the steps in FIGS. **2A** and **2B** either.

In the step S**1**, the sensor unit **10** senses a traveling speed of the pedelec **100** and a rotating speed of the pedal. The frequency for the sensor unit **10** to sense the traveling speed and the rotating speed is at least 20 times per second.

In the step S**11**, the processing unit **30** is used to determine whether one of the traveling speed and the rotating speed is equal to 0. If the traveling speed or the rotating speed is equal to 0, the step S**2** is to be executed; if both the traveling speed and the rotating speed are larger than 0, the following step SA is to be executed.

In the step S**2**, the processing unit **30** adjusts the assist level of the pedelec **100** to be the first assist level. Then, the process flow of the method is back to the step S**1**. In an embodiment, the first assist level is a maximum assist level at which the pedelec **100** can provide maximum auxiliary force; that is, when the pedelec **100** is stationary (i.e. the traveling speed is equal to 0) or glides (i.e. the traveling speed is not equal to 0, but a rider does not pedal the pedal so that the rotating speed of the pedal is equal to 0), the processing unit **30** adjusts the assist level of the pedelec **100** to the maximum assist level.

In the step SA, the pedelec **100** is operated at an initial assist level, for example the first assist level or the second assist level. Then, the step SB is executed.

In the step SB, the sensor unit **10** detects a pedal position of the pedal. Then, the step SB**1** is executed.

In the following steps (including the steps SB**1**, SB**2**, SB**22**, SB**2'**, SB**3** and SB**3'**), the sensor unit **10** can measure a pedal torque index, and the pedal torque index is recorded in the storage unit **20**. The pedal torque index recorded in the storage unit **20** is transmitted to the processing unit **30**. The processing unit **30** compares the pedal torque index with a predetermined numeric section. The predetermined numeric section has an upper threshold UB and a lower threshold LB (shown in FIG. **4**). FIG. **3** is a schematic diagram illustrating positions of the pedal **40** of the embodiment according to the invention. FIG. **4** is a schematic diagram illustrating the predetermined numeric section of the embodiment according to the invention. As shown by FIG. **3**, the pedal **40** rotates clockwise. The rotation path of the pedal has a first position D**1** and a second position D**2**. Therein, the pedal **40** will pass the first position D**1** and then pass the second position D**2**. The pedal **40** in FIG. **3** is located between the first position D**1** and the second position D**2**. The processing unit **30** compares the pedal torque indices with the predetermined numeric section in FIG. **4** according the different positions of the pedal **40**.

In the step SB**1**, the method is to determine whether the pedal position detected by the sensor unit **10** is located between the first position and the second position. If the pedal position is located between the first position and the second position, the method is to execute the step SB**2'**, or otherwise the method is to execute the step SB**2**. As shown by FIG. **3**, the pedal **40** will pass the first position D**1** and then reach the second position D**2**, so the process flow will execute the step SB**2'** at least one time prior to the step SB**2**.

In the step SB**2'**, the sensor unit **10** measures an instant torque value corresponding to a current position of the pedal **40**, and the instant torque value is recorded in the storage unit **20**. For example, when the pedal **40** is located at the position P**1**, a measured instant torque value is F(P**1**); when the pedal **40** is located at the position P**2**, a measured instant torque value is F(P**2**); similarly, when the pedal **40** is located at the position PN, a measured instant torque value is F(PN). Then, the instant torque values F(P**1**), F(P**2**) . . . F(PN) are recorded in the storage unit **20**. Then the method is to execute the step SB**3'**.

In the step SB**3'**, the processing unit **30** compares the instant torque value measured at the current position with the upper threshold of the predetermined numeric section and determines whether the instant torque value is higher than the upper threshold of the predetermined numeric section. When the instant torque value is higher than the upper threshold of the predetermined numeric section, the step SE is to be executed, or else the step SC is to be executed. In other words, the measured instant torque value at the current position is to be a pedal torque index for the execution of the step SB**3'**.

In the step SE, the processing unit **30** adjusts the assist level of the pedelec **100** to the first assist level (i.e. the maximum assist level in the embodiment). Then, the process flow of the method is back to the step SB.

The step SC indicates that the pedal torque index is within the predetermined numeric section, so the processing unit **30** maintains the current assist level of the pedelec **100**. If one of the following conditions is satisfied, the process flow of the method is get into the step SC: if (1) in the step SB**3'**, the instant torque value is lower than the upper threshold of the predetermined numeric section, or (2) in the step SB**3** later, a maximum torque value among the plurality of instant torque

values measured during the pedal **40** moving from the first position D**1** toward the second position D**2** is higher than the lower threshold of the predetermined numeric section, the assist level of the pedelec **100** is maintained unchanged. Then, the process flow of the method is back to the step SB.

In the step SB**2**, the method is to determine whether the pedal position is located at the second position D**2**. When the pedal position is located at the second position D**2**, the step SB**3** is to be executed, or else the step SB**22** is to be executed.

The step SB**22** indicates that the pedal has passed the second position, so the plurality of instant torque values recorded in the storage unit **20** is to be reset before the pedal enters the section of "the first position—the second position" again. Then, the process flow of the method is back to the step SB.

In step SB**3**, the processing unit **30** compares the maximum torque value among the plurality of instant torque values measured during the pedal **40** moving from the first position D**1** toward the second position D**2** with the lower threshold of the predetermined numeric section, and determines whether the maximum torque value among the instant torque values is lower than the lower threshold of the predetermined numeric section. If the maximum torque value among the instant torque values measured during the pedal **40** moving from the first position D**1** toward the second position D**2** is lower than the lower threshold of the predetermined numeric section, the step SD is to be executed, or otherwise the step SC is to be executed. In other words, the maximum torque value among the plurality of instant torque values measured during the pedal **40** moving from the first position D**1** toward the second position D**2** is to be a pedal torque index for the execution of the step SB**3**.

In the step SD, the processing unit **30** adjusts a current assist level parameter of the pedelec **100** to a next lower level. But the invention is not limited thereto. For example, it is assumed that the pedelec **100** has N-stage assist levels. If the current assist level of the pedelec **100** is the first assist level, the processing unit **30** adjusts the assist level of the pedelec **100** to the second assist level; if the current assist level of the pedelec **100** is the Nth assist level, the processing unit **30** adjusts the assist level of the pedelec **100** to the $(N+1)^{th}$ stage assist level. Then, the process flow of the method is back to step SB.

In an embodiment, the first position is same as the second position. That is, the step SD is executed once in every rotation cycle of the pedal.

As shown by FIG. **4**, the predetermined numeric section is defined according to a comfort zone CZ for a rider during riding. The predetermined numeric section allows the rider to adjust the lower threshold and the upper threshold thereof, but an interval between the lower threshold and the upper threshold is preferably kept to be a constant torque difference, e.g. 10 N-m (i.e. newton meter). If a torque value measured by the sensor unit **10** is higher than the upper threshold UB of the comfort zone CZ, it indicates that the muscles in the legs of the rider suffer excessive loading, so it is needed to enhance the auxiliary force provided by the pedelec **100** by increasing the assist level of the pedelec **100**. If a torque value measured by the sensor unit **10** is lower than the lower threshold LB of the comfort zone CZ, it indicates that the muscles in the legs of the rider suffer less loading leading to a discomfort due to void pedaling, so it is needed to reduce the auxiliary force provided by the pedelec **100** by decreasing the assist level of the pedelec **100**.

However, every rider has a different body shape and muscle power, so every rider has a different feeling in comfort. There-

fore, the invention allows the rider to adjust the lower threshold and the upper threshold of the predetermined numeric section by himself.

FIG. **5** is a schematic diagram illustrating a plurality of degrees of difficulty of the predetermined numeric section of the embodiment according to the invention. Because the interval between the lower threshold and the upper threshold of the predetermined numeric section is kept to be a constant torque difference (e.g. 10 N-m), when the value domain of the predetermined numeric section is higher values, it is uneasy for the pedal torque index to be higher than the upper threshold of this predetermined numeric section. Therefore, in this case, it is difficult to increase the assist level of the pedelec **100**. Furthermore, the pedal torque index tends to be lower than the lower threshold of the predetermined numeric section easily, so that the assist level of pedelec **100** tends to be reduced. In other words, in this case, the rider needs to apply more much force to the pedal **40** of the pedelec **100** for smooth riding.

On the contrary, when the value domain of the predetermined numeric section is lower, it is easy for the pedal torque index to be higher than the upper threshold of this predetermined numeric section, so that the assist level of the pedelec **100** is increased. Furthermore, it is uneasy for the pedal torque index to be lower than the lower threshold of the predetermined numeric section, so that the assist level of the pedelec **100** will not be decreased. In other words, in this case, the rider can ride smoothly just with applying quite less force to the pedal **40** of the pedelec **100**.

Hence, as shown by FIG. **5**, the invention allows the rider to set the predetermined numeric section to one of three levels: difficult, medium and easy. When the predetermined numeric section is set to be the easy level, the lower threshold and the upper threshold thereof can be 10 N-m and 20 N-m respectively. When the predetermined numeric section is set to be the medium level, the lower threshold and the upper threshold thereof can be 20 N-m and 30 N-m respectively. When the predetermined numeric section is set to be the difficult level, the lower threshold and the upper threshold thereof can be 30 N-m and 40 N-m respectively.

The rider can perform the above level adjustment of the predetermined numeric section by use of a human machine interface (HMI) on the pedelec **100** or a portable electronic device e.g. a smart phone, a tablet and so on.

The following are exemplary embodiments for further understanding of the method for automatic adjustment of a pedelec disclosed by to the invention. It is added that the exemplary embodiments are just specific instances according to the invention and are not used to limit the invention.

First Embodiment

FIG. **6** is a schematic diagram illustrating varying of the assist level, the speed and a pedal torque of the pedelec of the first embodiment according to the invention. It is interpreted first that the pedelec of the first embodiment is to run on a horizontal ground, and the comfort zone CZ for the rider is from 20 N-m to 30 N-m. Therefore, the predetermined numeric section is set to the medium level (i.e. its lower threshold and its upper threshold are 20 N-m and 30 N-m respectively). The assist levels of the pedelec are classified into 6 levels: $0\sim5^{th}$ levels. Therein, the 0 level presents that the pedelec provides no auxiliary force; the 5th level presents that the pedelec provides the most auxiliary force. Counting of rotation cycles of the pedal starts from the time the pedelec is still stationary (i.e. the speed is equal to 0); therein, the pedal is located at the first position, and the count of the rotation cycles of the pedal is 0. When the pedal re-passes the first position at the first time, the count of the rotation cycles of the

pedal is 1. When the pedal re-passes the first position at the second time, the count of the rotation cycles of the pedal is 2; and so forth.

As shown by FIG. **6**, the pedelec starts from stationary. At first, a torque applied by the rider (or applied to the pedal) exceeds 40 N-m. At the time, the assist level of the pedelec is set to be the 5th level, i.e. the maximum assist level. Because of the auxiliary force provided by the pedelec, the torque value decreases rapidly. When the count of the rotation cycles of the pedal is 1, because the maximum torque value measured during the count of the rotation cycles of the pedal being 0~1 is not lower than the lower threshold (20 N-m) of the predetermined numeric section, the assist level of the pedelec is still maintained to be the 5th level. When the count of the rotation cycles of the pedal is 2, because the maximum torque value measured during the count of the rotation cycles of the pedal being 1~2 is lower than the lower threshold (20 N-m) of the predetermined numeric section, the assist level of the pedelec is adjusted downward to a next lower level so that the assist level is set to be the 4th level. When the count of the rotation cycles of the pedal is 3, because the maximum torque value measured during the count of the rotation cycles of the pedal being 2~3 is lower than the lower threshold (20 N-m) of the predetermined numeric section, the assist level of the pedelec is adjusted downward to a next lower level so that the assist level is set to be the 3rd level. When the count of the rotation cycles of the pedal is 4, because the maximum torque value measured during the count of the rotation cycles of the pedal being 3~4 is lower than the lower threshold (20 N-m) of the predetermined numeric section, the assist level of the pedelec is adjusted downward to a next lower level so that the assist level is set to be the 2nd level. When the count of the rotation cycles of the pedal is 5 or 6, because the maximum torque value measured during the count of the rotation cycles of the pedal being 4~5 or 5~6 correspondingly is higher than the lower threshold (20 N-m) of the predetermined numeric section, and the torque values during the above periods are all within the predetermined numeric section (i.e. the comfort zone of 20 N-m to 30 N-m for the rider), the assist level of the pedelec is still maintained to be the 2nd level.

As discussed above, during the period of the count of the rotation cycles of the pedal being 0~4, the torque is not steady within the predetermined numeric section (i.e. 20 N-m to 30 N-m), so the speed of the pedelec and the assist level of the pedelec are still under an adjustment state. During the period of the count of the rotation cycles of the pedal being 4~5, the torque exceeds the lower threshold (20 N-m) so as to get in the comfort zone for the rider. During the period of the count of the rotation cycles of the pedal being 5~6, the torque is steady within the predetermined numeric section, the speed of the pedelec and the assist level of the pedelec all tends to be constant. During the period from that the count of the rotation cycles of the pedal exceeds 4 and the torque enters the predetermined numeric section to that the count of the rotation cycles of the pedal reaches 6, the torque is steady within the predetermined numeric section, so the speed of the pedelec and the assist level of the pedelec are under an equilibrium state.

Second Embodiment

FIG. **7** is a schematic diagram illustrating varying of the assist level, the speed and a pedal torque of the pedelec of the second embodiment according to the invention. Similar to the first embodiment, the pedelec of the second embodiment is to run on a common ground, and the comfort zone CZ for the rider is from 20 N-m to 30 N-m. Therefore, the predetermined numeric section is set to the medium level (i.e. its lower threshold and its upper threshold are 20 N-m and 30 N-m

respectively). The assist levels of the pedelec are classified into 6 levels: 0~5th levels. Therein, the 0 level presents that the pedelec provides no auxiliary force; the 5th level presents that the pedelec provides the most auxiliary force. Counting of rotation cycles of the pedal starts from the time the pedelec is still stationary (i.e. the speed is equal to 0); therein, the pedal is located at the first position, and the count of the rotation cycles of the pedal is 0. When the pedal re-passes the first position at the first time, the count of the rotation cycles of the pedal is 1. When the pedal re-passes the first position at the second time, the count of the rotation cycles of the pedal is 2; and so forth.

As shown by FIG. **7**, the pedelec starts from stationary. At first, a torque applied by the rider (or applied to the pedal) exceeds 40 N-m. At the time, the assist level of the pedelec is set to be the 5th level, i.e. the maximum assist level. Because of the auxiliary force provided by the pedelec, the torque value starts to decrease. When the count of the rotation cycles of the pedal is 1, because the maximum torque value measured during the count of the rotation cycles of the pedal being 0~1 is not lower than the lower threshold (20 N-m) of the predetermined numeric section, and the torque values are still higher than the upper threshold (30 N-m) of the predetermined numeric section during the count of the rotation cycles of the pedal being 1, the assist level of the pedelec is still maintained to be the maximum assist level (i.e. the 5th level). When the count of the rotation cycles of the pedal is 2, because the maximum torque value measured during the count of the rotation cycles of the pedal being 1~2 is not lower than the lower threshold (20 N-m) of the predetermined numeric section, the assist level of the pedelec is still maintained to be the 5th level. When the count of the rotation cycles of the pedal is 3, 4, 5 or 6, because the maximum torque value measured during the count of the rotation cycles of the pedal being 2~3, 3~4, 4~5 or 5~6 correspondingly is higher than the lower threshold of the predetermined numeric section, and the torque values during the above periods are all within the predetermined numeric section (i.e. the comfort zone of 20 N-m to 30 N-m for the rider), the assist level of the pedelec is still maintained to be the 5th level.

As discussed above, during the period of the count of the rotation cycles of the pedal being 0~1, the torque is not steady within the predetermined numeric section (i.e. 20 N-m to 30 N-m), so the speed of the pedelec and the assist level of the pedelec are still under an adjustment state. During the period from that the count of the rotation cycles of the pedal exceeds 1 and the torque enters the predetermined numeric section to that the count of the rotation cycles of the pedal reaches 6, the torque is steady within the predetermined numeric section, so the speed of the pedelec and the assist level of the pedelec tends to be constant, which shows an equilibrium state.

In addition, it can be understood based on the first and second embodiments above that the pedelec of each embodiment runs on a common ground, and the predetermined numeric section is set to be the medium level (i.e. the lower threshold and the upper threshold are 20 N-m and 30 N-m respectively). However, in the first embodiment, the rider rides the pedelec by a low gear ratio, so that the speed at the equilibrium state is relatively low (about 10 km/h); in the second embodiment, the rider rides the pedelec by a high gear ratio, so that the speed at the equilibrium state is relatively high (about 23 km/h).

As discussed above, the method for automatic adjustment of a pedelec of the invention not only is convenient for the rider to manipulate with less loading on the rider in learning, but also can automatically switch the pedelec to operate at a most proper assist level according to a current speed, a

cadence of the pedal, pedaling torque and so on so that the rider can experience an easy and comfortable riding.

Those skilled in the art will readily observe that numerous modifications and alterations of the device and method may be made while retaining the teachings of the invention. Accordingly, the above disclosure should be construed as limited only by the metes and thresholds of the appended claims.

What is claimed is:

1. A method for automatic adjustment of a pedelec, the pedelec having a first assist level and a second assist level, auxiliary force provided by the pedelec at the second assist level being less than auxiliary force provided by the pedelec at the first assist level, the pedelec comprising a pedal, the method comprising the following steps:

(A) operating the pedelec at an initial assist level;

(B) measuring a pedal torque index and comparing the pedal torque index with a predetermined numeric range, the predetermined numeric range being defined between an upper threshold and a lower threshold, and the upper threshold is higher than the lower threshold;

(C) if the pedal torque index is within the predetermined numeric range, keeping the pedelec in operating at the initial assist level;

(D) if the pedal torque index is lower than the lower threshold, adjusting the pedelec to operate at the second assist level; and

(E) if the pedal torque index is higher than the upper threshold, adjusting the pedelec to operate at the first assist level.

2. The method of claim 1, before the step (A), further comprising the following steps:

(1) sensing a traveling speed of the pedelec and a rotating speed of the pedal;

(2) if the traveling speed or the rotating speed is equal to 0, adjusting the pedelec to operate at the first assist level and returning back to the step (1); and

(3) executing the steps (A) to (E) only when both the traveling speed and the rotating speed are larger than 0.

3. The method of claim 1, wherein a rotation path of the pedal has a first position and a second position, and the step (B) comprises the following steps:

(B1) detecting a pedal position of the pedal;

(B2) recording a plurality of instant torque values measured during the pedal moving from the first position toward the second position, and assigning a maximum torque value among the instant torque values as the pedal torque index; and

(B3) when the pedal position passes through the second position, comparing the pedal torque index with the lower threshold and passing a result of the comparing to the step (D).

4. The method of claim 3, wherein the first position being same as the second position, the maximum torque value among the instant torque values in a rotation cycle of the pedal is assigned as the pedal torque index, and the step (D) is executed once in every rotation cycle of the pedal.

5. The method of claim 1, wherein a rotation path of the pedal has a first position and a second position, and the step (B) comprises the following steps:

(B1') detecting a pedal position of the pedal;

(B2') when the pedal position is between the first position and the second position, measuring an instant torque value, assigning the instant torque value as the pedal torque index, comparing the pedal torque index with the upper threshold, and passing a result of the comparing to the step (E); and

(B3') re-detecting a pedal position of the pedal, and when the pedal position is still between the first position and the second position, returning back to the step (B2').

6. The method of claim 1, wherein the lower threshold and the upper threshold are capable of being adjusted by a user, and an interval between the lower threshold and the upper threshold is kept to be a constant torque difference.

7. A method for automatic adjustment of a pedelec, the pedelec being capable of outputting auxiliary force at a first assist level, a second assist level and a third assist level selectively, the auxiliary force provided by the pedelec at the first assist level being larger than the auxiliary force provided by the pedelec at the second assist level, the auxiliary force provided by the pedelec at the second assist level being larger than the auxiliary force provided by the pedelec at the third assist level, a next lower level for the first assist level being the second assist level, a next lower level for the second assist level being the third assist level, the pedelec comprising a pedal, a rotation path of the pedal having a first position and a second position, the pedelec having a current assist level parameter and a predetermined numeric range, the predetermined numeric range being defined between an upper threshold and a lower threshold, the upper threshold being higher than the lower threshold, the method comprising the following steps:

(A) assigning one of the first assist level and the second assist level to the current assist level parameter;

(B) detecting a pedal position of the pedal;

(C) when the pedal position is between the first position and the second position,

(C1) measuring and recording an instant torque value;

(C2) if the instant torque value is higher than the upper threshold, assigning the first assist level to the current assist level parameter; and

(C3) if the instant torque value is lower than the upper threshold, maintaining the current assist level parameter; and

(D) when the pedal position passes through the second position,

(D1) determining a maximum torque value among a plurality of instant torque values measured and recorded during the pedal moving from the first position toward the second position;

(D2) if the maximum torque value is lower than the lower threshold, adjusting the current assist level parameter to the next lower level for the assist level that is assigned to the current assist level parameter; and

(D3) if the maximum torque value is higher than the lower threshold, maintaining the current assist level parameter.

8. The method of claim 7, wherein the step (C) further comprises a step (C4) returning back to the step (B), and the step (D) further comprises a step (D4) returning back to the step (B).

9. The method of claim 7, before the step (A), further comprising the following steps:

(1) sensing a traveling speed of the pedelec and a rotating speed of the pedal;

(2) if the traveling speed or the rotating speed is equal to 0, assigning the first assist level to the current assist level parameter and returning back to the step (1); and

(3) executing the steps (A) to (D) only when both the traveling speed and the rotating speed are larger than 0.

10. A method for automatic adjustment of a pedelec, the pedelec being capable of operating at a first assist level, a second assist level and a third assist level selectively, auxil-

iary force provided by the pedelec at the first assist level being larger than auxiliary force provided by the pedelec at the second assist level, the auxiliary force provided by the pedelec at the second assist level being larger than auxiliary force provided by the pedelec at the third assist level, a next lower level for the first assist level being the second assist level, a next lower level for the second assist level being the third assist level, the pedelec having a pedal, a current assist level parameter, and a predetermined numeric range, the predetermined numeric range being defined between an upper threshold and a lower threshold, the upper threshold being higher than the lower threshold, the method comprising the following steps:

   (A) assigning one of the first assist level and the second assist level to the current assist level parameter;

   (B) measuring a pedal torque index;

   (C) comparing the pedal torque index with the upper threshold, and if the pedal torque index is higher than the upper threshold, assigning the first assist level to the current assist level parameter;

   (D) comparing the pedal torque index with the lower threshold, and if the pedal torque index is lower than the lower threshold, adjusting the current assist level parameter to the next lower level for the assist level that is assigned to the current assist level parameter; and

   (E) if the pedal torque index is higher than the lower threshold and lower than the upper threshold, maintaining the current assist level parameter.

11. The method of claim **10**, a rotation path of the pedal having a first position and a second position, wherein the step (D) comprises the following steps:

   (D1) detecting a pedal position of the pedal; and

   (D2) when the pedal position passes through the second position, comparing the pedal torque index with the lower threshold.

12. The method of claim **11**, wherein the step (B) comprises the following step:

   (B1) recording a plurality of instant torque values measured during the pedal moving from the first position toward the second position, and assigning a maximum torque value among the instant torque values to the pedal torque index.

13. The method of claim **10**, a rotation path of the pedal having a first position and a second position, wherein the steps (B) and (C) comprise the following steps:

   (1) detecting a pedal position of the pedal;

   (2) when the pedal position is between the first position and the second position, measuring an instant torque value, assigning the instant torque value to the pedal torque index, and comparing the pedal torque index with the upper threshold; and

   (3) re-detecting a pedal position of the pedal, and when the pedal position is still between the first position and the second position, returning back to the step (2).

14. The method of claim **10**, wherein in each rotation cycle of the pedal, an execution count for the step (D) is less than an execution count for the step (C).

15. The method of claim **10**, wherein the lower threshold and the upper threshold are capable of being adjusted by a user, and an interval between the lower threshold and the upper threshold is kept to be a constant torque difference.

16. The method of claim **15**, wherein the constant torque difference is 10 newton meter.

17. The method of claim **10**, before the step (A), further comprising the following steps:

   (1) sensing a rotating speed of the pedal;

   (2) if the rotating speed is equal to 0, adjusting the pedelec to output at the first assist level and returning back to the step (1); and

   (3) executing the steps (A) to (E) only when the rotating speed is larger than 0.

18. The method of claim **10**, before the step (A), further comprising the following steps:

   (1) sensing a traveling speed of the pedelec;

   (2) if the traveling speed is equal to 0, adjusting the pedelec to output at the first assist level and returning back to the step (1); and

   (3) executing the steps (A) to (E) only when the traveling speed is larger than 0.

19. The method of claim **17**, wherein a frequency for sensing the rotating speed is at least 20 times per second.

20. The method of claim **18**, wherein a frequency for sensing the traveling speed is at least 20 times per second.

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